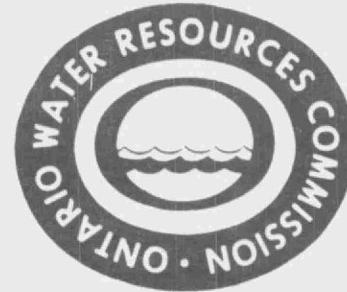


BBCZ



**REPORT
on
WATER QUALITY
in
LEONARD LAKE**

1971

RECREATIONAL LAKES PROGRAM

Copyright Provisions and Restrictions on Copying:

This Ontario Ministry of the Environment work is protected by Crown copyright (unless otherwise indicated), which is held by the Queen's Printer for Ontario. It may be reproduced for non-commercial purposes if credit is given and Crown copyright is acknowledged.

It may not be reproduced, in all or in part, for any commercial purpose except under a licence from the Queen's Printer for Ontario.

For information on reproducing Government of Ontario works, please contact ServiceOntario Publications at copyright@ontario.ca

BBCZ

16 -04- 1997
PDB library

THE
ONTARIO WATER RESOURCES COMMISSION

REPORT
ON WATER QUALITY
IN
LEONARD LAKE

1971

GENERAL TABLE OF CONTENTS

LIST OF FIGURES.....	ii
LIST OF TABLES.....	iii
SUMMARY.....	iv
INTRODUCTION.....	1
AREA DESCRIPTION.....	3
FIELD AND LABORATORY METHODS	
Physical, Chemical and Biological Field Methods..	6
Physical, Chemical and Biological Laboratory	
Methods.....	7
Bacteriological Field Methods and Laboratory	
Methods.....	7
Bacteriological Statistical Methods.....	8
DISCUSSION OF RESULTS	
Temperature and Dissolved Oxygen.....	10
pH, Alkalinity and Free Carbon Dioxide.....	10
Hardness, Conductivity, Chloride and Iron.....	10
Kjeldahl Nitrogen and Total Phosphorus.....	10
Chlorophyll a	12
Benthic Algal Growth.....	14
Bacteriology.....	15
TABLES.....	20
EXPLANATION OF TERMS IN BACTERIOLOGICAL TABLES.....	22
GLOSSARY.....	27
BIBLIOGRAPHY.....	31

LIST OF FIGURES

	Page
Figure 1 Map of Leonard Lake showing shoreline development, topography as well as chemical and biological sampling stations.....	5
Figure 2 Temperature and dissolved oxygen profiles in Leonard Lake, Station 36 (a) August 28, 1971 and (b) October 20, 1971.....	11
Figure 3 The relationship between chlorophyll <u>a</u> and Secchi disc as determined from the recreational lakes surveyed in 1971 as well as the individual values for Leonard Lake.....	13
Figure 4 Bacterial densities in May, 1971.....	16
Figure 5 Bacterial densities in August, 1971.....	17
Figure 6 Bacterial densities in October, 1971.....	18

LIST OF TABLES

	Page
Table 1 Iron, Hardness, Total Phosphorus, Kjeldahl Nitrogen, Chloride and Conductivity for Leonard Lake, 1971.....	20
Table 2 Chlorophyll <u>a</u> and Secchi disc values for Station 36 on Leonard Lake, 1971.....	21
Table 3 Summary of Analysis of Variance Grouping of Stations for Total Coliforms per 100 ml.....	23
Table 4 Summary of Analysis of Variance Grouping of Stations for Fecal Coliform per 100 ml.....	24
Table 5 Summary of Analysis of Variance Grouping of Stations for Fecal Streptococcus per 100 ml.....	25

SUMMARY

A study to evaluate the status of water quality in Leonard Lake was carried out during the summer of 1971.

Leonard Lake lies in the Precambrian Shield and is characterized by rolling hills, good local drainage and shallow overburden covering Precambrian bedrock. The shoreline is covered with a thin layer of sandy loam. Rock outcrop dominates most of the shoreline. Both the nature of the soils and topography surrounding the lake can be considered as unsuitable for cottage development utilizing standard subsurface septic tank systems.

Thermal stratification was observed in Leonard Lake. A metalimnetic oxygen decrease was evident during the August and October surveys coupled with severe oxygen depletions and reduced pH values in the bottom waters.

Although concentrations of chlorophyll a were well below nuisance levels reflecting the unproductive nature of the main body of the lake large gelatinous masses of filamentous algae Zygnema were present in abundance in the near-shore areas of the southern bay and to a much lesser extent in shallow waters of the main body of the lake. These near-shore growths provide evidence that conditions of accelerated eutrophy are developing in Leonard Lake.

The chemical water quality was characteristic of soft-water Precambrian lakes. The use of detergents containing phosphorus is unnecessary in such soft water and should be avoided by area residents.

Nitrogen and phosphorus concentrations in the main body of the lake were low and would not be expected to cause any serious algal problems in that area.

Leonard Lake had good bacteriological water quality and was well within the OWRC criteria for total body contact recreational use during all three surveys.

Unless efforts are made to ensure that direct flow or leachate from domestic waste disposal systems and other potential sources of pollution do not gain access to the lake, future water quality will be undermined.

INTRODUCTION

Maintenance of good water quality in recreational lakes in the Province of Ontario is of vital concern to the Ontario Water Resources Commission, the Ontario Department of the Environment and other governmental agencies involved in tourism and the control and management of shoreline development of cottages and resorts. In 1970 an interdepartmental program was established to survey a number of recreational lakes in order to detect and correct sources of water pollution and ensure that our lakes would be well managed to protect water quality. The Ontario Department of Health, whose jurisdiction in this program was transferred to the Department of the Environment in December 1971, would carry out on-shore inspection and correction of faulty private waste disposal systems, whereas the Ontario Water Resources Commission would evaluate the existing water quality of the respective lakes. A record of the present status of the private waste disposal systems and the lake water quality would also be documented for comparative use in any future studies.

Recreational lakes are subjected to two major types of water quality impairment; bacteriological contamination and excessive growths of algae and aquatic weeds (eutrophication). The two problems may result from a common source of wastes but the consequences of each are quite different. Bacteriological contamination by raw or inadequately treated sewage poses an immediate public health hazard if the water is used for bathing. In order for this to occur, raw wastes or septic tank effluents must gain entry to the lake although it may not be obvious upon visual inspection of the site. It must be noted that no surface water is considered safe for human consumption without prior treatment including disinfection. The algae and weed problems which have come into prominence in recent years are caused by plant nutrients being added to the lake. Excessive algae and weed growths impair aesthetic values and recreational use of a lake but seldom pose a health hazard. There are nutrient sources other than sewage wastes which do not create serious bacterial hazards but do support nuisance plant growths such as agricultural fertilizer losses and normal nutrient runoff from forest and field.

In line with its responsibility of evaluating the status of water quality in recreational lakes, the Ontario Water Resources Commission undertook a study on Leonard Lake in the summer of 1971. Three surveys were conducted; a spring survey from May 21 to 25, a mid-summer survey from August 26 to 30 and a fall survey from October 17 to 21 inclusive. The scope of the work included the assessment of the bacteriological, physical, chemical and biological conditions of the lake with stress being placed on the bacteriological and nutrient enrichment problems.

Sampling surveys were conducted on an intensive basis (sampling each day for a minimum of five days) which is mandatory for an accurate assessment of bacteriological conditions.

In addition to the results obtained from these studies, information from other governmental agencies has been incorporated in this report which is the Ontario Water Resources Commission's contribution to the Interdepartmental Task Force Report which will deal with the overall cottage pollution program in Ontario.

AREA DESCRIPTION

Geography and Topography

Leonard Lake is located in the Township of Muskoka Lakes, District Municipality of Muskoka approximately 11 kilometers (7 miles) west of the urban area of the Town of Bracebridge.

Leonard Lake has a surface area of 2 square kilometers (0.7 square miles) and an irregular shoreline 14 kilometers (9 miles) in length. It has a maximum depth of 15 meters (50 feet) with a total volume of 14 cubic hectometers (11,600 acre feet).

The immediate watershed of the lake consists of 7 square kilometers (2.7 square miles) of land lying within the Precambrian Shield and having a gradual to steep sloping topography. It is moderately to heavily forested with a mixture of deciduous and coniferous trees often reaching the edge of the rocky shoreline. The surrounding soil belongs to the Monteagle series which is a granitic sandy loam glacial till with a Podzol profile providing good drainage. Rock outcrop is frequent and the soil cover is thin and extremely stony. The east shore of the bay in the south tip of the lake is swampy and the south shore of the bay has a small sandy beach. In most areas the soil depth is less than the minimum of five feet required by the Department of the Environment for the installation of standard subsurface septic tank systems.

Climatic Range

The area has a mean daily temperature of -9°C (15°F) in January and a mean temperature of 19°C (66°F) in July. The mean annual precipitation is 1 meter (40 inches) including 3 meters (116 inches) of snow. According to the meteorological records, the area enjoys about 200 days with no measurable precipitation. The summer climate is conducive to most recreational activities and the winter with its abundance of snow provides for participation in most winter sports.

Water Movement

Leonard Lake is a small body of water with no constant surface inflow. Its only outlet is a small creek near Station 32 (Figure 1) which empties into Milford Bay in Lake Muskoka. The outlet has an overflow dam which is owned and operated by the Township of Muskoka Lakes.

Shoreline Development

There are approximately 100 cottages and 1 lodge on Leonard Lake. The shoreline of the lake is well developed except for the northwest shore (Figure 1). The southwest shore is the most densely populated with approximately half of the lake's cottages on it.

Water Usage

The majority of the cottage owners use the lake water as their source of domestic supply. The lake supports recreational water sports such as fishing, boating, water skiing and swimming. According to information from the Department of Lands and Forests, the species of fish in the lake are smallmouth bass, yellow pickerel, yellow perch, lake whitefish and pumpkinseed. Fish planting has been carried out since 1947. Since that time 3,000,000 yellow pickerel eggs, 250,000 yellow pickerel fry and 21,000 smallmouth bass fingerlings and fry have been planted. Stocking of yellow pickerel was discontinued in 1956 as was smallmouth bass in 1964. An experimental stocking of Rainbow Trout was made in 1968. An assessment of angling activity and harvest of the stocked species will be intensified by the Department of Lands and Forests.

At the present time there are no discharges of raw or treated wastes into Leonard Lake from municipal or industrial sewage treatment facilities. The area residents are provided with a municipal solid waste disposal site located on lot 22, concession 7 in the Township of Muskoka Lakes (Monck). The site does not appear to be posing any pollution hazard to the lake.

FIGURE 1



0 1/4 1/2 3/4 1

ONTARIO WATER RESOURCES COMMISSION

RECREATIONAL LAKES PROGRAM

LEONARD LAKE

1971 WATER QUALITY SURVEY

SCALE: AS SHOWN

DRAWN BY: R.S.

DATE: MARCH 1972

CHECKED BY:

DRAWING NO: 72-25-D.E.B.

FIELD AND LABORATORY METHODS

Physical, Chemical and Biological Field Methods

Physical, chemical and biological water quality surveys were conducted from May 21 to 25, August 26 to 30 and from October 17 to 21 inclusive. One inlet station (32) and two mid-lake stations (36 and 44) were selected for physical, chemical and biological sampling.

Dissolved oxygen and temperature profiles were determined daily in the field using a combination dissolved oxygen-telethermometer unit. Total alkalinity and free carbon dioxide were measured daily titrimetrically and pH was measured with a portable pH meter. Daily chlorophyll samples were collected in a 32-ounce bottle at Station 36 utilizing a composite sampler lowered through the euphotic zone (2X Secchi disc) and immediately preserved with 10 - 15 drops of 2% $MgCO_3$.

At least once, a 32-ounce sample for hardness, alkalinity, chloride, total phosphorus, total Kjeldahl nitrogen, iron and conductivity was collected at stations 32, 36 and 44. Stations 36 and 44 were sampled using a composite sampler through the euphotic zone. At Station 32, samples were collected from 1 meter of depth using a Kemmerer sampler.

On October 21, at Station 36, a sample for total phosphorus, total Kjeldahl nitrogen and iron was obtained by means of a Kemmerer sampler from a depth of 1m above the bottom.

Physical, Chemical and Biological Laboratory Methods

All analyses were carried out using routine OWRC methods based on Standard Methods 13th Edition.

Iron was measured after the sample had been digested with acid to dissolve all forms of iron present.

Kjeldahl nitrogen and total phosphorus were determined after the sample was digested with acid and an oxidizing agent to destroy organic matter.

For chlorophyll determinations, 1 liter samples were filtered through a 1.2 μ membrane filter which was then extracted with 90% acetone for 24 hours. Absorbance of the extract was determined at wavelengths 600 to 750 mu using a Unicam SP1800 ultra violet spectrophotometer. The concentrations of chlorophyll a were calculated using the equation given by Richards and Thompson (1952).

Bacteriological Field and Laboratory Methods

Five day intensive bacteriological surveys were completed on Leonard Lake during May, August and October. Sixteen stations were sampled each day at a depth of 1 meter below the surface using sterile, autoclavable, polycarbonate, 250 ml bottles. An additional sample was collected at station 36D (Figure 4) one meter above the bottom using a modified "piggy-back" sampler and sterile 237 ml evacuated rubber air syringes. All samples were stored on ice and delivered to the mobile laboratory within two to six hours and analyzed for total coliforms, fecal coliforms and fecal streptococcus using the membrane filtration technique (MF) (Standard Methods 13th Edition) except that m-Endo Agar Les (Difco) was used for total coliform and MacConkey membrane broth (Oxoid) was used for fecal coliform determinations. The total coliforms (TC) fecal coliforms (FC) and fecal streptococcus (FS) were used as "indicators" of fecal pollution. These "indicators" are the normal flora of the large intestine, and are present in large numbers in the feces of man and animals. When water is polluted with fecal material, there is a potential danger that pathogens or disease causing micro-organisms may also be present.

The coliform group is defined, according to Standard Methods 13th Edition, as "all of the aerobic and facultative anaerobic, gram-negative, mon-sporeforming rod-shaped bacteria which ferment lactose with gas formation within 48 hours at 35°C" and, or "all organisms which produce a colony with a golden green metallic sheen within 24 hours of incubation" using the MF technique.

This definition includes, in addition to the intestinal forms of the Escherichia coli group, closely related bacteria of the genera Citrobacter and Enterobacter. The Enterobacter-Citrobacter groups are common in soil, but are also recovered in feces in small numbers and their presence in water may indicate soil runoff or, more important, less recent fecal pollution since these organisms tend to survive longer in water than do members of the Escherichia group, and even to multiply when suitable environmental conditions exist. A more specific test for coliforms of intestinal origin is the fecal coliform test, with incubation of the organisms at 44.5°C. Though by no means completely selective for Escherichia coli, this test has proved useful as an indicator of recent fecal pollution.

Fecal streptococci (or enterococci) are also valuable indicators of recent fecal pollution. These organisms are large, ovoid gram-positive bacteria, occurring in chains. They are normal inhabitants of the large intestine of man and animals, and they generally do not multiply outside the body. In waters polluted with fecal material, fecal streptococci are usually found along with coliform bacteria, but in smaller numbers, although in some waters they may be found alone. Their presence, along with coliforms, indicates that at least a portion of the coliforms in the sample are of fecal origin.

Bacteriological Statistical Methods

Fluctuations in bacterial concentrations due to changing environmental conditions require that a great number of samples be taken to arrive at a mean value which is representative of a specific sample location or sampling area. The most appropriate mean for bacterial numbers and this type of data is the geometric mean. The vast quantities of bacteriological data generated from these samples necessitated the development of additional statistical methods to summarize the mean results into

a more concise presentation. The statistical methods used are based on the analysis of variance. The stations on a lake can be grouped by this method into areas or groups of stations with the same statistical bacterial level, without the bias normally associated with manual interpretation.

The analysis of variance is particularly effective where bacterial concentrations vary slightly throughout the lake. Areas or stations with slight differences in bacterial concentrations can be isolated. Areas or stations with statistically higher bacterial numbers reliably indicate an input.

The results from all the analyses were organized as replicates representing the stations during the survey period. All data were transformed to logarithms (base 10) and all further analyses were done using these transformed data. A geometric mean (the antilogarithm of the average of the logarithm) was calculated on each station and for each parameter. The validity of the analysis of variance program (ANOVA-CRE: Burger, 1972), was based on the assumptions that the variances of all the stations were similar (Bartlett's test of Homogeneity) and that the data were normally distributed. Both these assumptions were checked on Leonard Lake. The Bartlett's test was found to be non-significant and the data followed abnormal distribution, hence the analysis of variance (F-test; Sokal, 1969) was calculated in all the stations. If the F was significant, then the multiple-t test was used to help determine the stations which should be deleted from the overall group to yield a homogeneous group of stations. The withdrawn stations were regrouped with respect to geographic proximity and similar means. The calculations on all groups were repeated using the analysis of variance program until each discrete group was homogeneous. The homogeneous groups that were geographically isolated were compared by means of the Student-t test (using the log GM and S.E.) which indicated the statistical difference between these groups. The Student-t test was also used to compare the grouped bacteriological data from the three surveys.

DISCUSSION OF RESULTS

Temperature and Dissolved Oxygen

During the August survey, a well defined thermocline, characterized by a temperature change of approximately 11°C was apparent between 8 and 12m (Figure 2a). An increase in oxygen was present in the lower epilimnion indicating an increase in photosynthetic activity at that depth. There was a rapid decline of oxygen (112% to 56% saturation) through the metalimnion (Figure 2b). Hypolimnetic oxygen concentrations were low.

In October, the thermocline was approximately two meters deeper than during the preceding survey (Figure 2a). A severe oxygen decline occurred through the metalimnion with a total absence of dissolved oxygen within the hypolimnion (Figure 2b). This hypolimnetic oxygen deficit results from bacterial oxidation of organic material, biological respiration and chemical oxidation of organic matter.

Hardness, Chloride, Conductivity and Iron

Hardness, chloride, conductivity and iron data (Table 1) were normal for soft-water Precambrian lakes and are consistent with each other confirming that no unusual mineral characteristics were present. Detergents containing phosphorus are unnecessary in such soft water and their use should be avoided by area residents.

Kjeldahl Nitrogen and Total Phosphorus

The nitrogen and phosphorus concentrations were quite low in the main body of the lake and would not be expected to cause any algal problems in the surface water.

pH, Total Alkalinity and Free Carbon Dioxide

Surface pH values in Leonard Lake were acidic, being consistent with many soft-water Precambrian Lakes. In the surface waters, pH was generally higher than that of the bottom waters. Specifically, on August 29, at Station 36, values at 1 and 14 m were 5.7 and 5.0 respectively. Total alkalinity was low with similar values at the surface and in the deeper strata.

Figure 2a

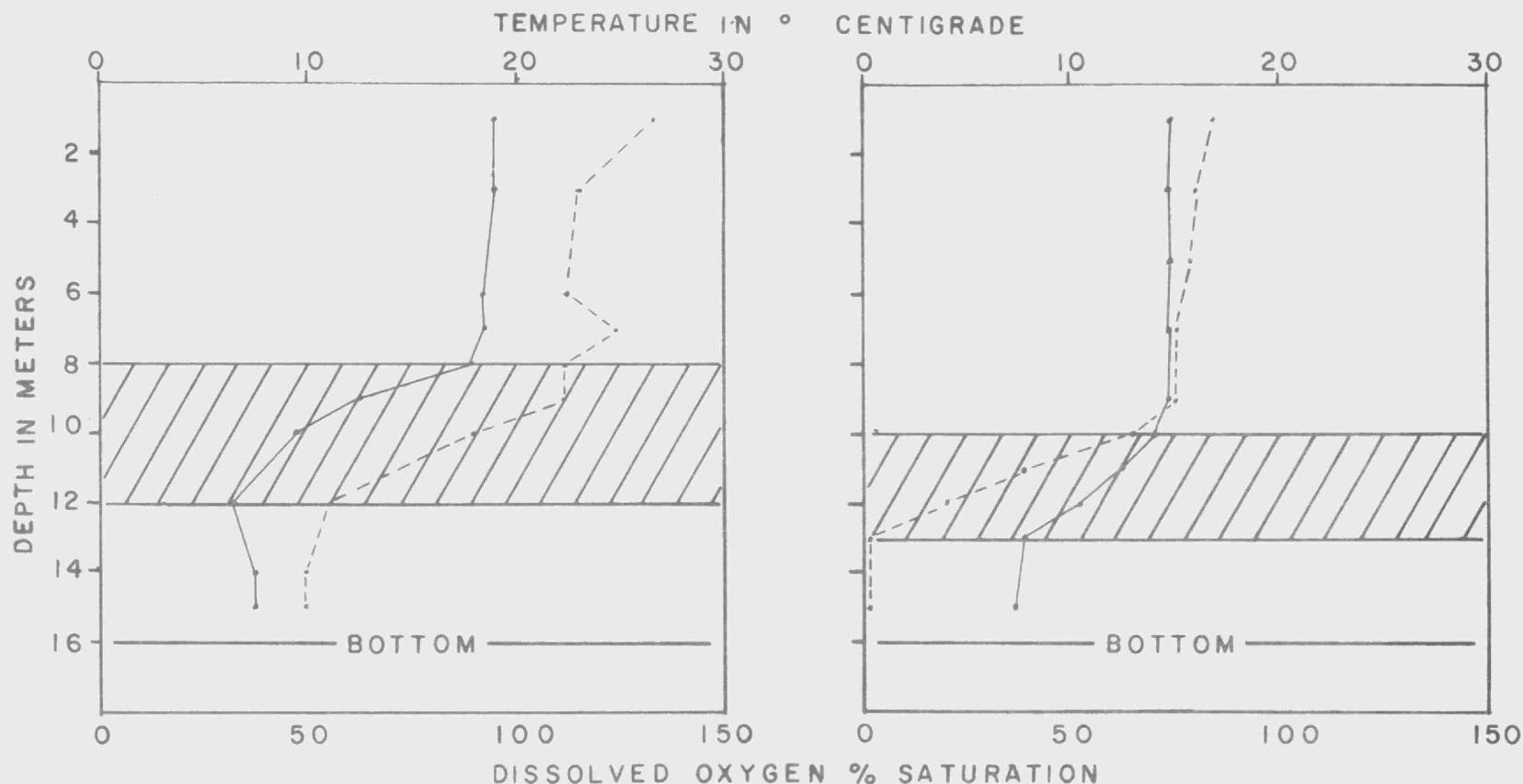
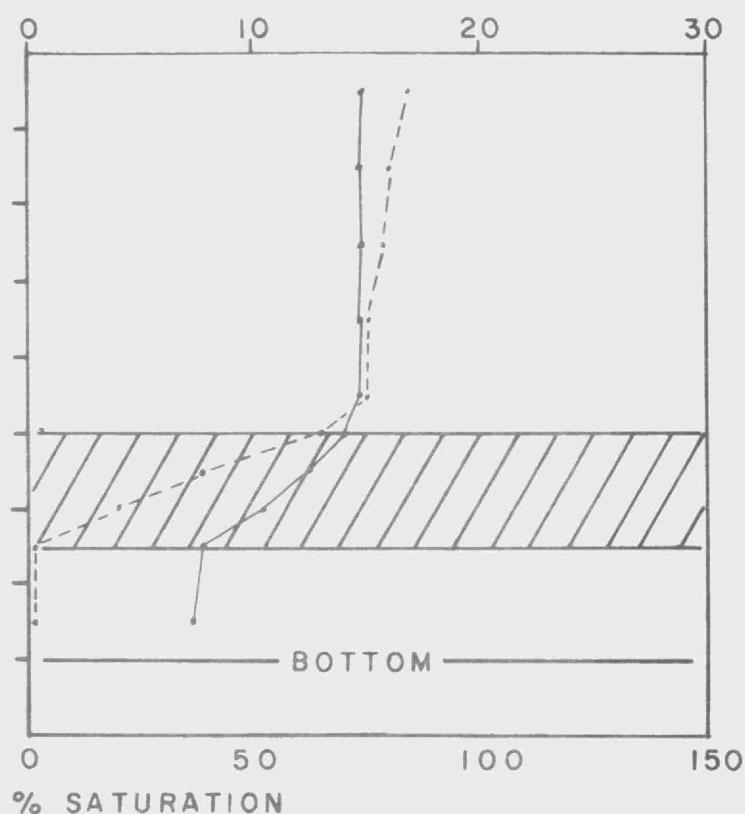


Figure 2b



— Temperature
- - - Dissolved Oxygen

Figure 2: Temperature and dissolved oxygen profiles in Leonard Lake, Station 36 on (a) August 28, 1971 and (b) October 20, 1971. The shaded areas approximate the position of the thermocline.

Occasionally, values were slightly higher in the bottom waters.

Free carbon dioxide values were generally higher in the bottom waters than in the warmer surface waters. For example, on August 26 at Station 36, concentrations at 1 and 14m were 1.8 and 14.8 mg/l respectively.

Reduced pH values in the bottom waters are due to the accumulation of carbon dioxide derived from organic decomposition while the increased alkalinity is related to the release of bicarbonate from sediments by bacterial and chemical action in conjunction with calcium, magnesium, iron, manganese and ammonia.

Chlorophyll a

The chlorophyll a concentrations and Secchi disc values from Station 36 are presented in Table 1. Chlorophyll a concentrations were low during the three sampling periods ranging from 0.6 to 1.2 µg/l, 2.7 to 3.5 µg/l and 1.2 to 1.7 µg/l for the May, August and October surveys respectively. These values were low and reflect a low productive capacity or oligotrophic status of the lake.

Water clarity, which is one of the more important parameters used in defining water quality, may be measured using a Secchi disc. Figure 3, presents a chlorophyll a-Secchi disc relationship for a number of surface waters and clarifies the 'trophic status' of Leonard Lake in relation to numerous other well known recreational lakes in the Province (see Brown 1972 for derivation of chlorophyll a - Secchi disc relationship). With respect to Figure 3 Leonard Lake is positioned between values observed for the oligotrophic lakes Superior, and Huron and the more mesotrophic Lake Ontario and the Eastern Basin of Lake Erie. The lake was well removed from the Bay of Quinte, Gravenhurst Bay and Riley Lake, ~~three~~ extremely enriched bodies of water.

FIGURE 3

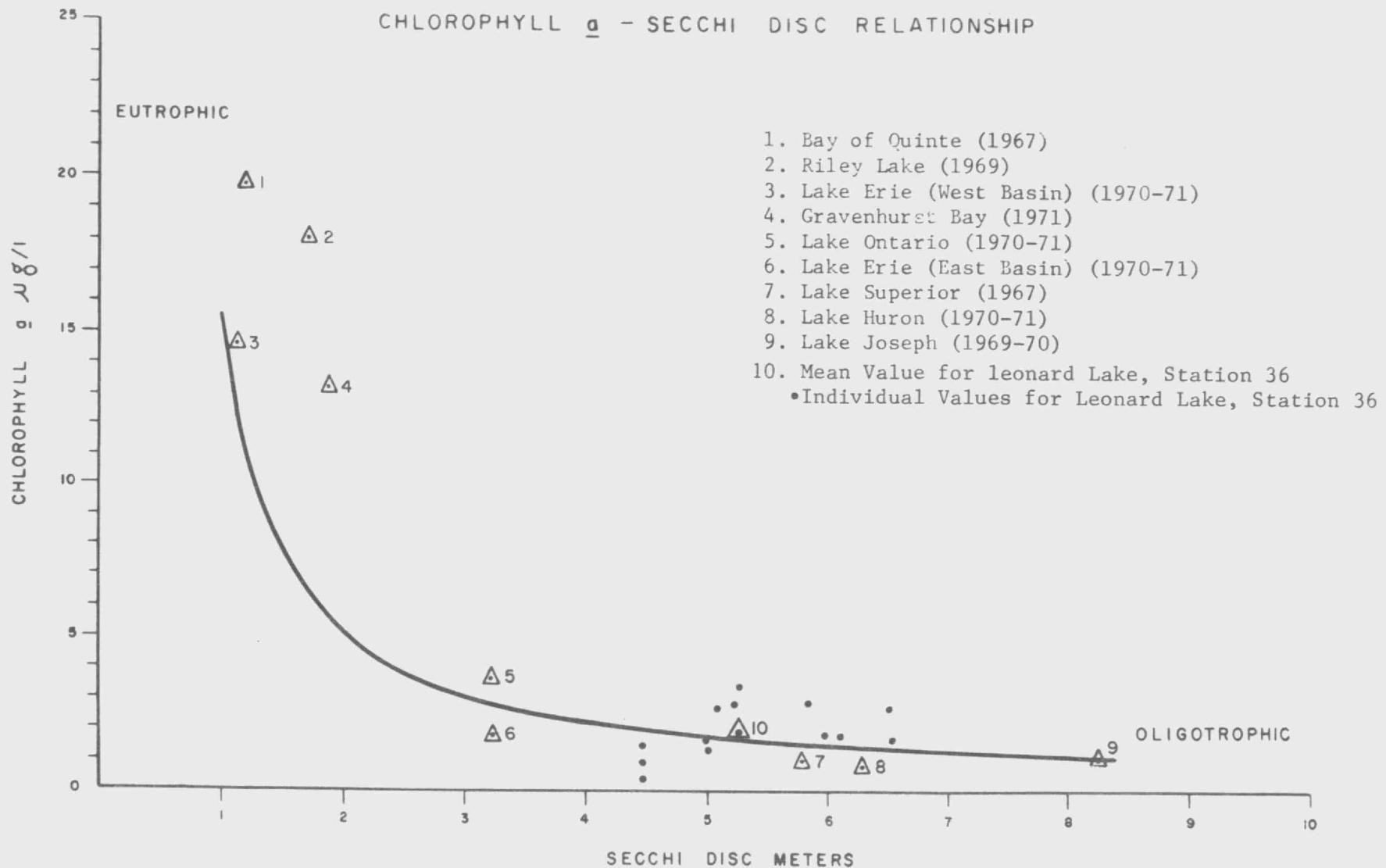
CHLOROPHYLL a - SECCHI DISC RELATIONSHIP

Figure 3: The relationship between chlorophyll a and Secchi disc as determined from the recreational lakes surveyed in 1971 as well as the individual chlorophyll a - Secchi disc values for Leonard Lake. The Great Lakes data was added for comparative purposes.

Benthic Algae Growth

Large gelatinous masses of the filamentous green alga Zygnema were present in abundance in the southern bay of Leonard Lake. These vast growths have materialized only over the last 2 - 4 years, according to local cottagers. Distribution was limited only to the southern bay in 1970, but in 1971, masses of Zygnema were found in small shallow bays in the southern most portions of the main water body. This increased distribution indicated that this nuisance algal form was rapidly spreading within Leonard Lake and constitutes evidence of accelerated eutrophication.

Bacteriology

Leonard Lake, during all three surveys was well within the OWRC criteria for total body contact recreational use of 100 TC/100 ml, 100 FC/100 ml and 20 FS/100 ml based on a geometric mean of at least 10 samples in one month (OWRC, 1970).

The overall mean bacteria levels during the three surveys in 1971 are summarized as follows:

PARAMETER	MAY 21 - 25	AUGUST 26 - 30	OCTOBER 17 - 21
TC	13/100 ml	14/100 ml	51/100 ml
FC	1/100 ml	4/100 ml	1/100 ml
FS	1/100 ml	1/100 ml	3/100 ml

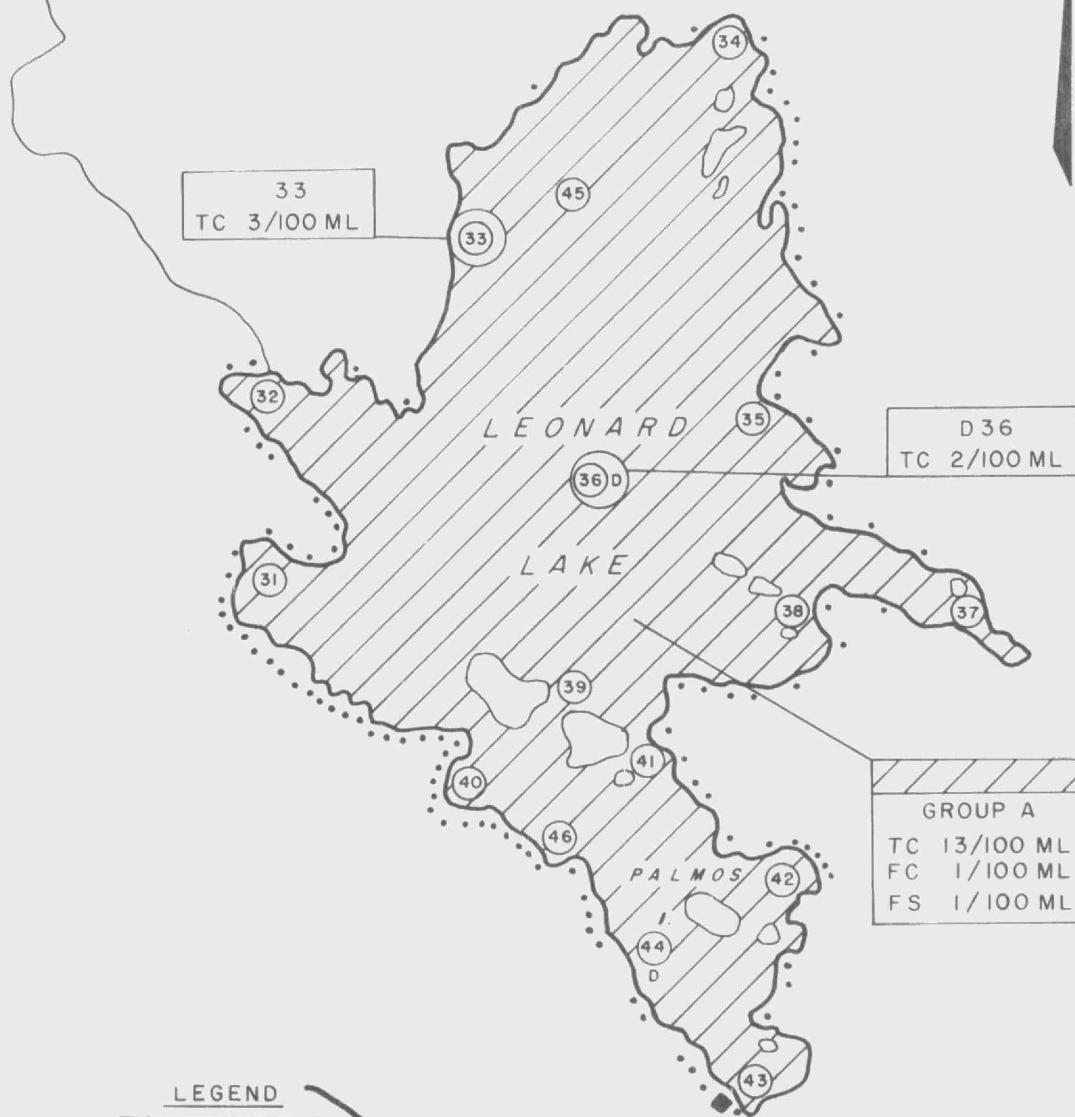
In the May survey, TC, FC and FS overall mean levels were very low in Group A (Figure 4). The only stations which differed significantly from Group A were Station 33, a sample point off the undeveloped northwest shore, and Station D36, a mid-lake depth station. These two areas had very low TC levels of 3/100 ml and 2/100 ml respectively. FC and FS concentrations were uniformly low throughout the lake (Tables 4, 5).

In August the TC, FC and FS levels remained very low throughout the lake (Figure 5). Group B on the swampy west shore of the southern bay had a significantly higher FS mean of 10/100 ml. Stations D44 and 46, within Group B, displayed significantly higher FC levels of 13/100 ml. These higher FC levels have been attributed to cottage development along that shore. Station 34, in a developed bay at the north end of the lake had significantly higher FC and FS levels of 9/100 ml.

Group A, in the October survey, with a mean TC level of 51/100 ml was statistically higher than Group A in the May and August surveys (Table 6). Station 37, in a shallow, swampy bay was significantly higher than Group A with a TC mean of 168/100 ml. The mid-lake stations (36, D36, 45), all showed lower TC

FIGURE 4

MAY SURVEY



ONTARIO WATER RESOURCES COMMISSION	
RECREATIONAL LAKES PROGRAM	
LEONARD LAKE	
1971 WATER QUALITY SURVEY	
SCALE : AS SHOWN	
DRAWN BY : R.S.	DATE : MARCH 1972
CHECKED BY :	DRAWING N°: 72-23-D.E.A

FIGURE 5

AUGUST SURVEY

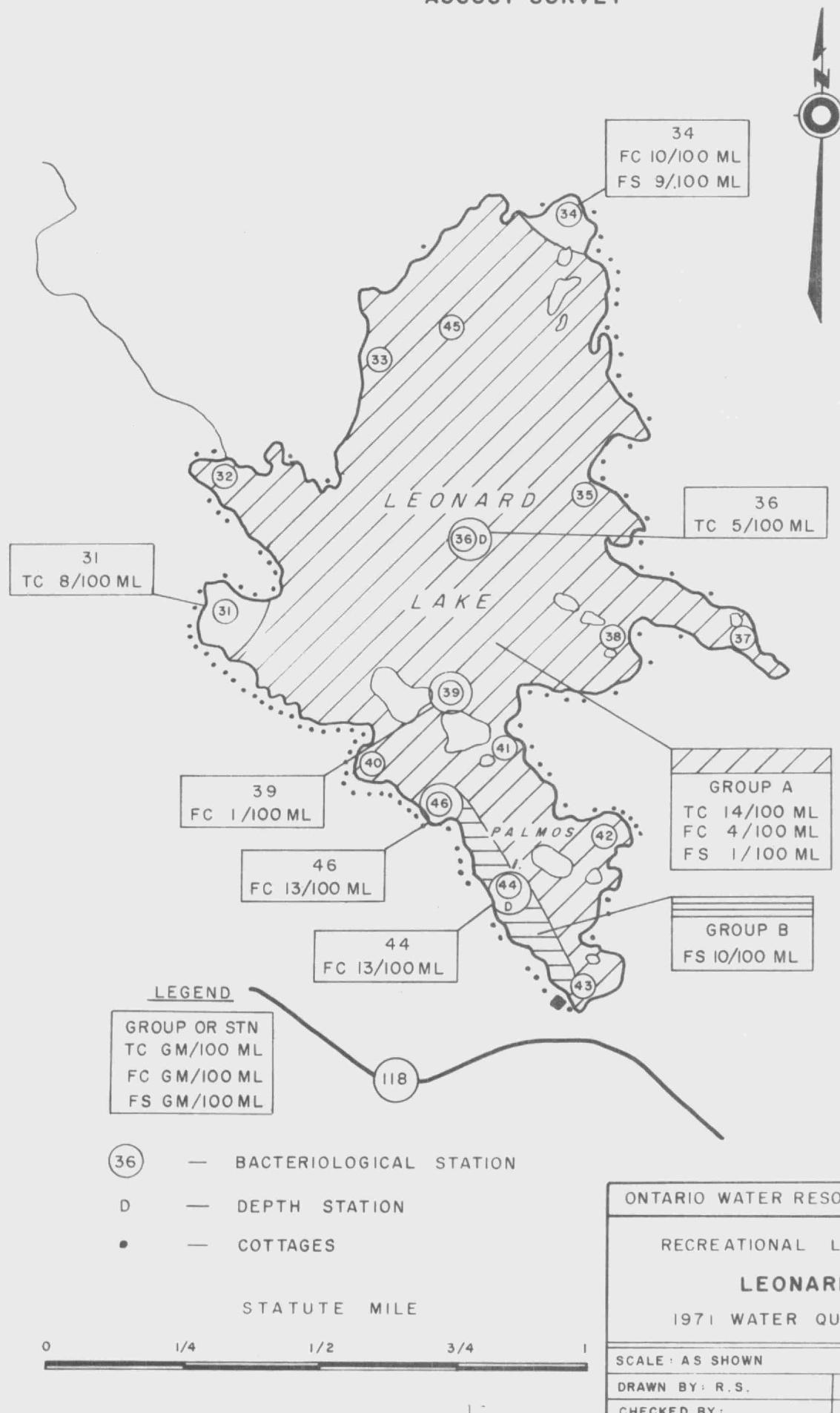
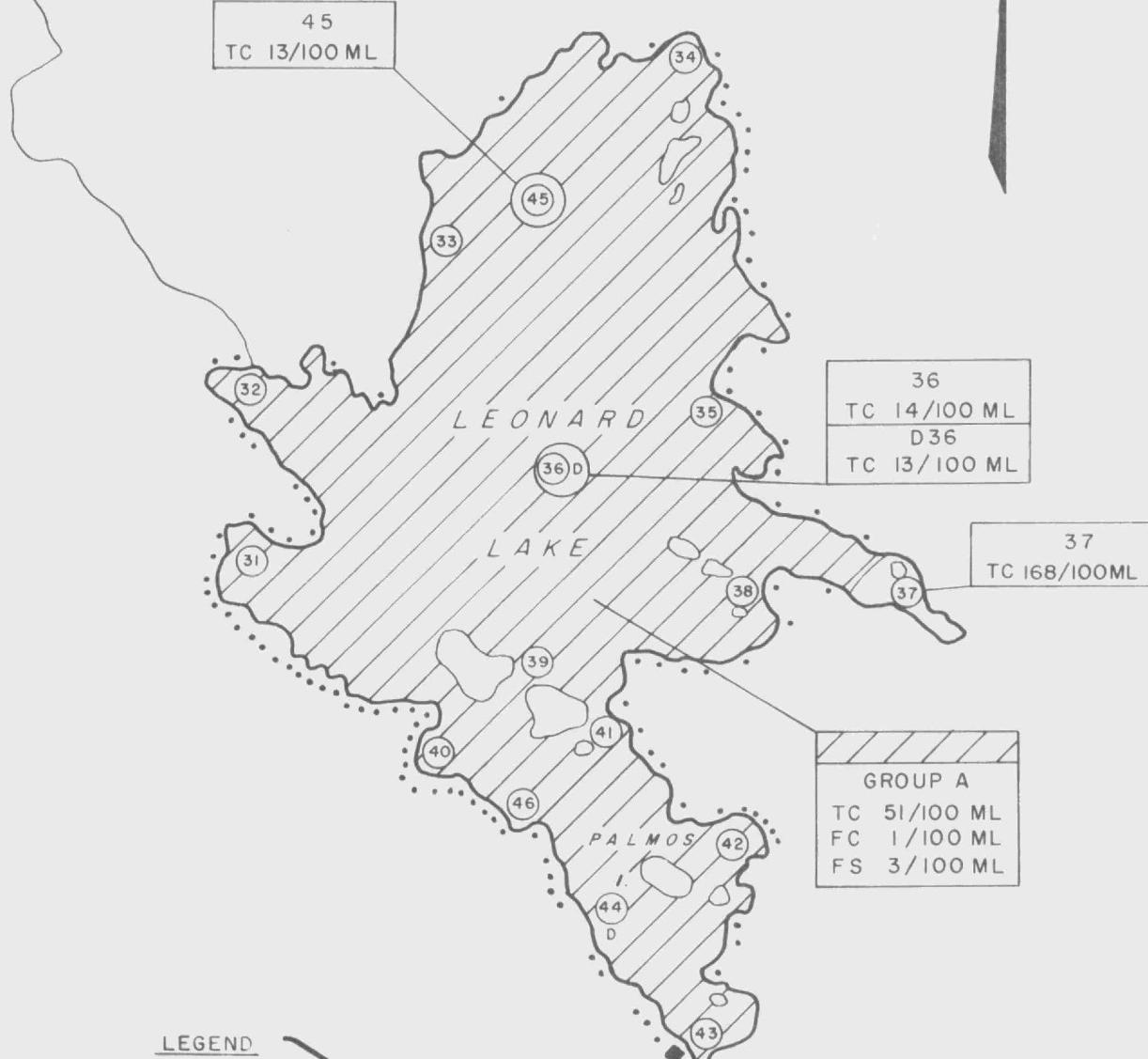


FIGURE 6

OCTOBER SURVEY



STATUTE MILE

0 1/4 1/2 3/4 1

ONTARIO WATER RESOURCES COMMISSION	
RECREATIONAL LAKES PROGRAM	
LEONARD LAKE	
1971 WATER QUALITY SURVEY	
SCALE AS SHOWN	
DRAWN BY: R.S.	DATE: MARCH 1972
CHECKED BY:	DRAWING NO: 72-23-D.E.A

levels than the rest of Leonard Lake.

Although Leonard Lake was well within the OWRC criteria for total body contact recreational use during the three survey periods, no surface water is considered potable without prior treatment including disinfection.

TABLE 1

Iron, Hardness (Hard), Total Phosphorus (P), Kjeldahl Nitrogen (N), Chloride (Cl), and Conductivity (Cond) for Leonard Lake, 1971.
The results are expressed as mg/l except conductivity which is $\mu\text{mhos}/\text{cm}^3$.

Station	Depth	Date	Iron	Hard.	P	N	Cl	Cond.
32	1m	30/8	0.05	10	0.010	0.19	2	35
32	1m	21/10	0.10	10	0.016	0.32	3	32
36	7m comp	21/5	0.15	11	0.014	0.26	2	-
36	9m comp	22/5	0.10	13	0.014	0.23	2	-
36	9m comp	24/5	0.15	12	0.012	0.29	2	-
36	9m comp	25/5	0.15	11	0.016	0.36	2	-
36	10m comp	30/8	0.05	10	0.010	0.15	3	33
36	14m	30/8	-	-	0.044	0.32	-	-
36	10m comp	21/10	0.05	10	0.008	0.47	3	33
36	15m	21/10	0.05	-	0.014	0.26	-	-

TABLE 2

Chlorophyll a and Secchi disc values for Station 36 on Leonard Lake,
during 1971.

	Chlorophyll a	Secchi Disc
May 21	0.8 µg/l	- m
May 22	0.6	4.5
May 23	0.8	4.5
May 24	-	4.5
May 25	1.2	4.5
August 26	2.8	6.5
August 27	2.9	5.8
August 28	3.5	5.3
August 29	2.9	5.3
August 30	2.7	5.1
October 17	1.2	5.0
October 18	1.5	6.0
October 19	1.6	6.0
October 20	1.4	6.5
October 21	1.7	5.0
<hr/>		
Mean	1.83	5.32

µg/l = micrograms per litre

m = metre

EXPLANATION OF TERMS IN BACTERIOLOGICAL TABLES

F	-	the calculated analysis of variance statistic on F ratio.
df	-	degrees of freedom of the F ratio for "between group" and "within group" variation.
F(5%)	-	the F ratio from a statistics table (Rohlf 1969). If the calculated F is greater than the F(5%), a significant difference (SD) occurred between the groups in the analysis. If the F is less than F(5%), no significant difference (NSD) occurred.
log GM	-	the logarithm (base 10) of the geometric mean.
S.E.	-	the standard error of the log GM where
		$S.E. = \frac{s}{\sqrt{n}} \quad \text{and } s = \text{standard deviation}$
N	-	the number of values in the mean.
GM	-	the geometric mean of the bacterial level.
t	-	the calculated test of significance or student t-test used to compare stations, groups and a survey. If t for the number of degrees of freedom shown is greater than the critical t value, a significant difference (SD) occurs.
		SD refers to a significant difference at the .05 level but no significant difference at the .01 level.
		SD* refers to a significant difference at the .01 level but no significant difference at the .001 level.
		SD** refers to a significant difference at the .001 level.

TABLE 3

Summary of Analysis of Variance Grouping of Stations

Parameter: Total Coliform

<u>SURVEY</u>	<u>May 21 - 26</u>	<u>August 26 - 30</u>	<u>October 17 - 21</u>
Group	All Stations	All Stations	All Stations
F	1.891	2.231	4.721
df	17, 65	17, 61	17, 72
F(.05)	1.786	1.796	1.771
	SD	SD	SD
Group	A All stations except 33, D36	A All stations except 31, D36	A All stations except 36, D36, 37, 45
F	0.347	1.114	1.8229
df	14, 59	15, 55	13, 56
F(.05)	1.840	1.857	1.86
	NSD	NSD	NSD
Log GM	1.240	1.505	1.707
SE	0.060	0.052	0.035
N	75	71	70
GM	13	14	51

TABLE 4

Summary of Analysis of Variance Grouping of Stations

Parameter: Fecal Coliform

<u>SURVEY</u>	<u>May 21 - 26</u>	<u>August 26 - 30</u>	<u>October 17 - 21</u>
Group	All Stations	All Stations	All Stations
F	1.0028	2.439	1.185
df	16, 64	17, 61	17, 72
F(.05)	1.84	1.796	1.771
	NSD	SD	NSD
Group	A	A All stations except 34, 39, D44, 46	A
F	1.0028	1.6787	1.185
df	16, 64	13, 47	17, 72
F(.05)	1.84	1.84	1.771
	NSD	NSD	NSD
Log GM	0.0319	0.5818	0.0636
SE	0.0138	0.048	0.0151
N	81	61	90
GM	1	4	1

TABLE 5

Summary of Analysis of Variance Grouping of Stations

Parameter: Fecal Streptococcus

<u>SURVEY</u>	<u>May 21 - 26</u>	<u>August 26 - 30</u>	<u>October 17 - 21</u>
Group	All Stations	All Stations	All Stations
F	0.623	3.097	0.700
df	16, 65	17, 61	32, 103
F(.05)	1.93 NSD	1.796 SD	1.563 NSD
Group	A	A All stations except 34, 43, 44, D44, 46	A
F	0.623	1.477	0.700
df	16, 65	12, 42	32, 103
F(.05)	1.93 NSD	2.04 NSD	1.563 NSD
Log GM	0.0441	0.3064	0.4593
SE	0.0139	0.044	0.0481
N	82	55	136
GM	1	2	3
Group	B		
	All Stations except 43, 44, D44, 46		
F	0.163		
df	3, 16		
F(.05)	4.77 NSD		
Log GM	0.977		
SE	0.1312		
N	19		
GM	10		

TABLE 6

Summary of Student-t tests Between Surveys for Total Coliforms

	May	August
October	$t = 6.5903$ $df = 143$ $t(.05) = 1.980$ SD**	$t = 3.2054$ $df = 139$ $t(.05) = 1.980$ SD**

GLOSSARY OF TERMS

ALKALINITY	:The alkalinity of a water sample is a measure of its capacity to neutralize acids. This capacity is due to carbonate, bicarbonate and hydroxide ions and is arbitrarily expressed as if all of the neutralizing capacity was due to calcium carbonate alone.
ANOXIC	:Refers to conditions when no oxygen is present.
BACKGROUND COLONIES	:Background colonies are other lake water bacteria capable of growing on the total coliform plate, in spite of the inherent restrictive conditions.
CHLORIDE	:Chloride is simply a measure of the chloride ion concentration and is not a measure of chlorination.
CHLOROPHYLL <u>a</u>	:A green pigment in plants.
CONDUCTIVITY	:Conductivity is a measure of the waters ability to conduct an electric current and is due to the presence of dissolved salts.
DIATOMS	:Unicellular plants found on all continents and in all types of water where light and nutrients are sufficient to support photosynthesis. They are comprised of two siliceous frustules (cell walls) which have an outer valve (epitheca) fitting over the inner valve (hypotheca) like the lid on a box. The siliceous deposits comprising the frustules vary in regular patterns according to the individual species.
EPILIMNION	:Is the thermally uniform layer of a lake lying above the thermocline. Diagram I.
EUPHOTIC ZONE	:The lighted region that extends vertically from the water surface to the level at which photosynthesis fails to occur due to insufficient light penetration.
EUTROPHIC	:Waters containing advanced nutrient enrichment and characterized by a high rate of organic production.

EUTROPHICATION	:The process of becoming increasingly enriched in nutrients. It refers to the entire complex of changes which accompanies increasing nutrient enrichment. The result is the increased production of dense biological growths such as algae and aquatic weeds which generally degrade water quality and render the lake unsuitable for many recreational activities.
FECAL COLIFORMS (FC)	:Fecal coliforms are bacteria associated with recent fecal pollution from man and animals.
FECAL STREPTOCOCCUS (FS)	:Fecal streptococcus are bacteria associated with fecal pollution from animals and to a lesser extent man.
HARDNESS	:Hardness of water is a measure of the total concentration of calcium and magnesium ions expressed as if all of the ions were calcium carbonate.
HYPOLIMNION	:The uniformly cold and deep layer of a lake lying below the thermocline, when the lake is thermally stratified. Diagram #1
KJELDAHL NITROGEN	:Sum of nitrogen present in the ammonia and organic forms (it does not include nitrite or nitrate).
MESTROPHIC	:Waters characterized by a moderate nutrient supply and organic production (i.e. midway between eutrophic and oligotrophic).
METALIMNION	:See thermocline.
OLIGOTROPHIC	:Waters containing a small nutrient supply and consequently characterized by a low rate of organic production.
pH	:Is the measure of the hydrogen ion concentration expressed as the negative logarithm of the molar concentration.
PHOSPHORUS (TOTAL)	:Sum of all forms of phosphorus present in the sample.

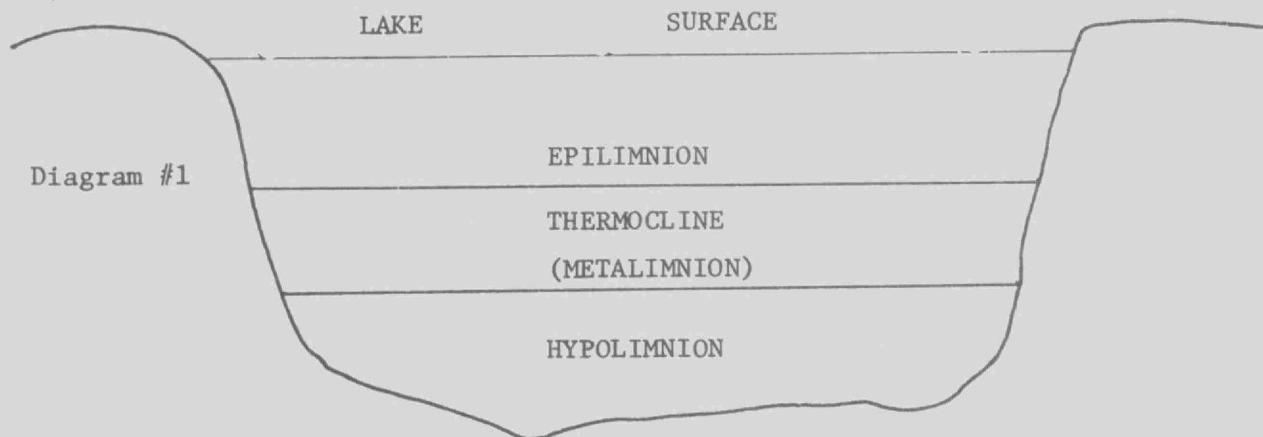
SECCHI DISC

:A circular metal plate, 20 centimeters in diameter, the upper surface of which is divided into four equal quadrants. Two quadrants directly opposite each other are painted black and the intervening ones white. The secchi disc is used to estimate the turbidity of the lake water.

THERMAL STRATIFICATION :During the spring, vertical temperatures in a lake are homogeneous from top to bottom. As summer advances, the surface waters become warmer and less dense than the underlying cooler waters. A strong thermal gradient (Thermocline) occurs giving rise to three distinct water layers. The variation in density between layers retards mixing by wind action and water currents. Diagram #1.

**THERMOCLINE
(metalimnion)**

:The layer of water located between the epilimnion and hypolimnion in which the temperature exhibits a decline equal to or exceeding 1°C increase per meter.

**TOTAL COLIFORMS (TC)**

:Total coliforms are bacteria commonly associated with fecal pollution but may also be present naturally in the environment.

TROPHIC STATUS

:Depending upon the degree of nutrient enrichment and resulting biological productivity, lakes are classified into three intergrading types:

TROPHIC STATUS

(continued)

:oligotrophic, mesotrophic and eutrophic.

If the supply of nutrients to an oligotrophic lake is progressively increased, the lake will become more mesotrophic in character and with continued enrichment it will become eutrophic.

BIBLIOGRAPHY

BENNETT, E.A. Taken from the Great Lakes as an Environment,
Edited by D.V. Anderson, Great Lakes Institute
Report PR 39, University of Toronto, October 1969

BROWN, D.J. 1972 Chlorophyll a - Secchi disc relationship
in Ontario Recreational Lakes (In Preparation).

BURGER, A. Statistical Bacterial Data Summarization and
Interpretation Internal OWRC Report (Unpublished).

Guidelines and Criteria for Water Quality Management in Ontario,
OWRC, June 1970.

Microbiological Criteria

Water used for body contact recreational activities should be free from pathogens including any bacteria, fungi or viruses that may produce enteric disorders or eye, ear, nose, throat and skin infections. Where ingestion is probable, recreational waters can be considered impaired when the coliform, fecal coliform, and/or enterococcus geometric mean density exceeds 1000, 100 and/or 20 per 100 ml respectively, in a series of at least ten samples per month, including samples collected during weekend periods.

RICHARDS, F.A. and THOMPSON , T.G. 1952 The estimation and Civilization of plankton populations by pigment analysis II. The spetrophotometric method for the estimation of plankton pigments. J. Marine Res., 11:156.

ROHLF, F.M. and SOKAL, R.R., 1969 Statistical Tables, W.H. Freeman and Company, San Francisco.

SOKAL, R.R. and ROHLF, F.J. 1969 Biometry, the principals and practices of statistics in biological research, W.H. Freeman and Company, San Francisco.

Standard Methods for the Examination of Water and Wastewater, 13th Edition, 1971. APHA, AWWA, WPCF.